Additional information should be obtained and recorded to determine the efficiency and cost of operating the digesters. This information includes the total and volatile suspended solids in the waste sludge, the daily ambient and basin temperatures, and the volume and concentration of digested sludge pumped to land disposal. A sample operations report form for the aerobic sludge digestion process is included in Appendix D.

D. ANNUAL LAND REQUIREMENTS

From the preceding analysis the minimum annual acreages required for land disposal of sludge in Tahlequah can be calculated to equal 17 acres for the existing treatment plant and 100 acres for the future facility. In practice, however, between two and four times the required minimum acreages must be secured for a sludge disposal program to be successful.

It is, therefore, recommended that the Tahlequah Public Works Authority initially secure between 60 and 80 acres on which to dispose of the sludge generated by the existing treatment plant. By the time the proposed wastewater treatment facility is constructed and the method of sludge disposal is converted from the present cake disposal operation to a liquid sludge disposal operation, sufficient additional acreage should be secured to accommodate the increased sludge production.

E. INTERIM OPERATION DURING CONSTRUCTION

As previously noted, digested sludge from the existing facility is wasted to the drying beds where it reaches a level II state before being removed and disposed of by application to land from a truck mounted dry box spreader. Following construction of the new treatment facility and subsequent change in the sludge stabilization scheme the sludge drying beds will no longer be required. In an effort to minimize the impact of the new facility on the floodplain of Tahlequah Creek, it may be necessary to construct the new biological basin complex in the area occupied by one-half of the drying beds. Because the loss of drying beds will impact the present method for obtaining a disposable sludge, some provision would have to be implemented during construction to satisfy the regulatory requirements related to the production of level II sludge.

Should a portion of the drying beds be removed from service to accommodate the new treatment facilities, the most likely scenario for obtaining level II sludge during construction will involve the installation of the proposed gravity belt thickener early in the construction process and operating the existing aerobic digestion system at a solids concentration high enough to assure level II sludge generation. Assuming that solids removed from the reaeration zone can be concentrated from 0.7 to 5 percent on the belt thickener it can be shown that the volume of sludge to the existing aerobic digesters can be reduced from 15,570 to 2,180 gallons per day (909 lbs. per day/0.05 x 8.34 lbs. per gallon = 2,180 gallons per day).

Each of the existing aerobic digestion compartments has a volume of 20,000 cubic feet on 150,000 gallons which results in a total aerobic digestion tank volume of 300,000 gallons. The resulting hydraulic detention time in the aerobic digesters at the thickened sludge concentration, therefore, will be approximately 138 days which is more than adequate to achieve level II sludge. Until the remainder of the sludge disposal system proposed for the new facility is constructed and operational, the sludge will continue to be dewatered using the drying beds that will be undisturbed by the construction of the new basin complex.

The proposed method for interim operation during construction will necessitate good project coordination on the part of the contractor as well as early equipment shop drawing review and approval for the gravity belt thickener and related appurtenances. In addition, temporary pumping equipment will be required to transfer sludge from the reaeration basin to the belt thickener and back again to the aerobic digestion units.

F. SITE SELECTION CRITERIA

The most critical step in developing a program for the land application of sludge is finding a suitable site. The characteristics of the site determine the actual design and influence the overall effectiveness of the disposal scheme. The site selection process should begin with an initial screening of potential sites on the basis of the factors and criteria outlined in Table 1. After the number of potential sites is narrowed, each site should be evaluated in detail.

TABLE 1

LAND APPLICATION SITE SUITABILITY CRITERIA

Parameter	Most Suitable	Conditions Less Suitable	Least Suitable
Depth to bedrock	6 feet or more	3 to 6 feet	3 feet or less
Depth to seasonal watertable	5 feet or more	3-5 feet	less than 3 feet
Slope	6 percent	6 to 12 percent	12 percent
Soil pH	6.5 or above	5.5 to 6.5	5.5 or below
Soil CEC	15 meq/100 g	5 to 15 meq/100 g	5 meq/100 g
Soil permeability	0.2 to 6.0 in/hr	0.06 to 0.2 in/hr	greater than 6.0 in/hr or less than 0.06 in/hr
Drainage	Well and moderately well drained	Somewhat excessively or somewhat poorly drained	Excessively, poorly and very poorly drained
Runoff	None, very slow, slow	Medium	Rapid, very rapid
Available water capacity	6.0 inches	3.0 to 6.0 inches	3.0 inches
Hydrologic soil group	A or B	C	D

The two most important criteria are depth to bedrock and depth to seasonal high water, because these conditions, if unfavorable, are difficult to mitigate. The hydrologic soil group (a measure of the soil runoff potential), the permeability of the limiting soil layer and the soil pH are less important, because they can be mitigated to some degree through proper engineering and agronomic practices.

To determine whether soils suitable for land application of sludge exist in the Tahlequah area, the "Soil Survey for Cherokee and Delaware Counties, Oklahoma", published by the USDA Soil Conservation Service was reviewed. After screening all of the soil types with respect to the criteria presented in Table 1, it was concluded that only eight soil types were suitable for land application of sludge: the Captina, Dennis, Jay, Newtonia and Sallisaw silt loams; the Locust cherty silt loams; and the Okemah and Summit silty clay loams.

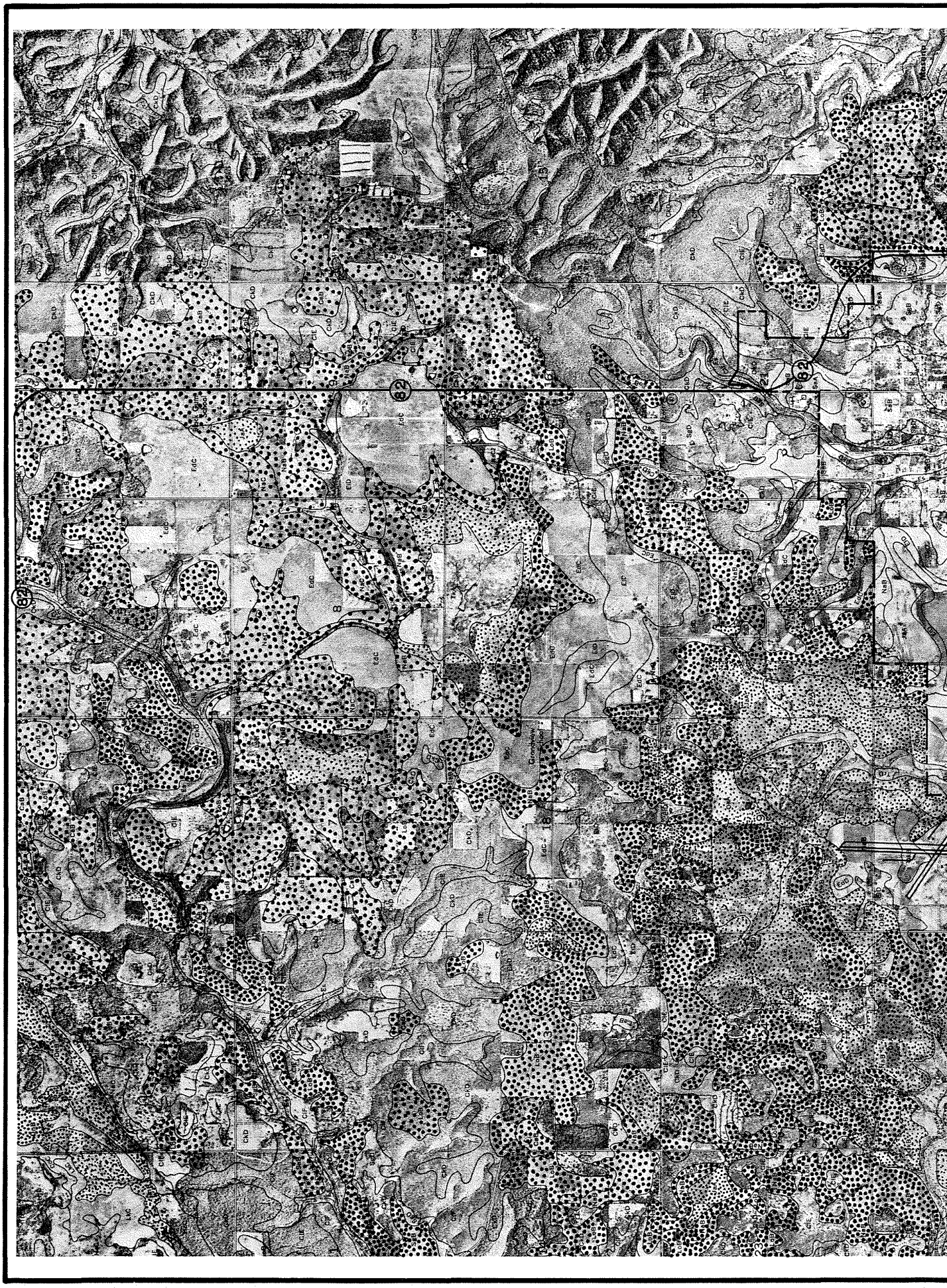
The eight soil types were further analyzed to determine which types contained the most soil characteristics suitable for land application of the sludge. The results of that analysis are presented in Table 2. Based on the data presented in this table, it can be seen that the Captina, Newtonia and Sallisaw silt loams and the Locust cherty silt loams are the most suitable soil types for land application of sludge near Tahlequah, Oklahoma.

TABLE 2

SUITABLE SOIL TYPES FOR LAND APPLICATION OF SLUDGE

Soil Series & Map Symbols	Hydrologic Soil Group	pH Value	Soil Permeability IN/HR	Remarks
Captina (CaB)	B	5.1-6.0	0.20 to 0.63	Suitable Soil
Dennis (DnB)	C	6.1-7.3	0.06 to 0.20	Less Suitable Soil
Jay (JaA)	C	5.1-6.0	0.06 to 0.20	Less Suitable Soil
Locust (LoB)	B	5.1-6.0	0.20 to 6.3	Suitable Soil
Newtonia (NaA,NaB,NaC)	B	5.6-6.5	0.63 to 2.0	Suitable Soil
Okemah (OkA,OkB,OkC)	C	5.6-6.5	0.06 to 0.20	Less Suitable Soil
Sallisaw (SaA,SaB,SgB)	B	5.6-6.5	0.63 to 2.0	Suitable Soil
Summit (SuC2)	C	5.6-7.3	0.06 to 0.20	Less Suitable Soil

Figure No. 6 shows the areas with the highest probabilities of containing soils suitable for land application of sludge, considering land use, land slope, ground water aquifers, depth to bedrock, and soil parameters.



IV. TECHNICAL ASSESSMENT OF SPECIFIC SITES

A. SOIL SAMPLING AND ANALYSIS

Once potential disposal sites have been identified, ownership should be determined and personal contact made with the property owners. The individuals involved in the initial owner contacts should be knowledgeable of both the benefits and constraints of the program.

After the initial contact has been made with the land owner and right-of-entry secured, a field investigation and soil testing program must be undertaken to verify the suitability of the soil types at the candidate site. The soil physical and chemical properties needed to properly evaluate sludge application sites include a soil profile, a determination of pH and soil buffer index, the cation exchange capacity (CEC), the plant available nitrogen, the plant available phosphorus, the plant available potassium, a background metals analysis, the soil conductivity, the calcium to magnesium ratio, chlorides , and the sodium absorption ratio.

Determinations of pH, lime requirements, and cation exchange capacity are generally needed to assess appropriate sludge application rates and site management practices. A soil pH of 6.5 or above is required by regulation to minimize migration of heavy metals. If soil pH is too low, lime additions must be used to raise soil pH to a proper level. The cation exchange capacity is an indication of the soil's ability to tie up heavy metals and prevent their migration. Soil CEC is also used as a guide in setting limits upon cumulative heavy metal loading in the sludge application to sites used for crops.

Recommended cumulative metal loadings for agricultural cropland are shown in Table 3.

TABLE 3

RECOMMENDED CUMULATIVE LIMITS FOR METALS (LBS/ACRE) OF MAJOR CONCERN APPLIED TO AGRICULTURAL CROPLAND

	Soil Cation Exchange Capacity (meq/100g)		
Metal	0-5	5-15	15 or greater
Pb	500	1000	2000
Zn	250	500	1000
Cu	125	250	500
Ni	50	100	200
Cd	4.46	8.92	17.84
Se	0.71		

Existing soil nutrient levels (i.e., N, P, and K), which are plant available, is useful information in calculating sludge application rates to the sludge application site when growing vegetation on the site.

As a general rule, one soil sample should be collected from a candidate site for each 25 to 40 acres with a minimum of one soil sample collected from each soil series in the field.

B. PHYSICAL FEATURES

The OSDH informational guidelines have also established minimum distances between an area receiving sludge and adjacent site features such as ponds and lakes, springs, water supply wells, and pubic road rights-of-way. The applicable site criteria relative to physical features adopted by the OSDH are as follows:

1. The distance to a well or spring used for domestic water supply purposes shall be 250 feet or greater.

2. The distance to a well used for public water supply purposes shall be 660 feet or greater.

3. The distance to a surface water body shall be 100 feet or greater.

4. The distance to the travelled portion of a roadway shall be 25 feet or greater.

5. Sludge shall not be applied within 10,000 feet of an airport utilized by turbojet aircraft nor within 5,000 feet of a public use airport utilized by piston engine aircraft unless prior approval has been received from the Federal Aviation Administration.

V. SITE PROCUREMENT

A site procurement procedure which includes many of the items previously discussed and culminates in the actual negotiation for the use, lease or purchase of land is shown on Figure No. 7. This activity diagram is intended to allow a site to be procured openly, with full understanding by all parties involved, and with a minimum potential for unnecessary expense or delay. In general the steps are as follows:

1. Identify a specific area (or areas) which appear to be acceptable sites.

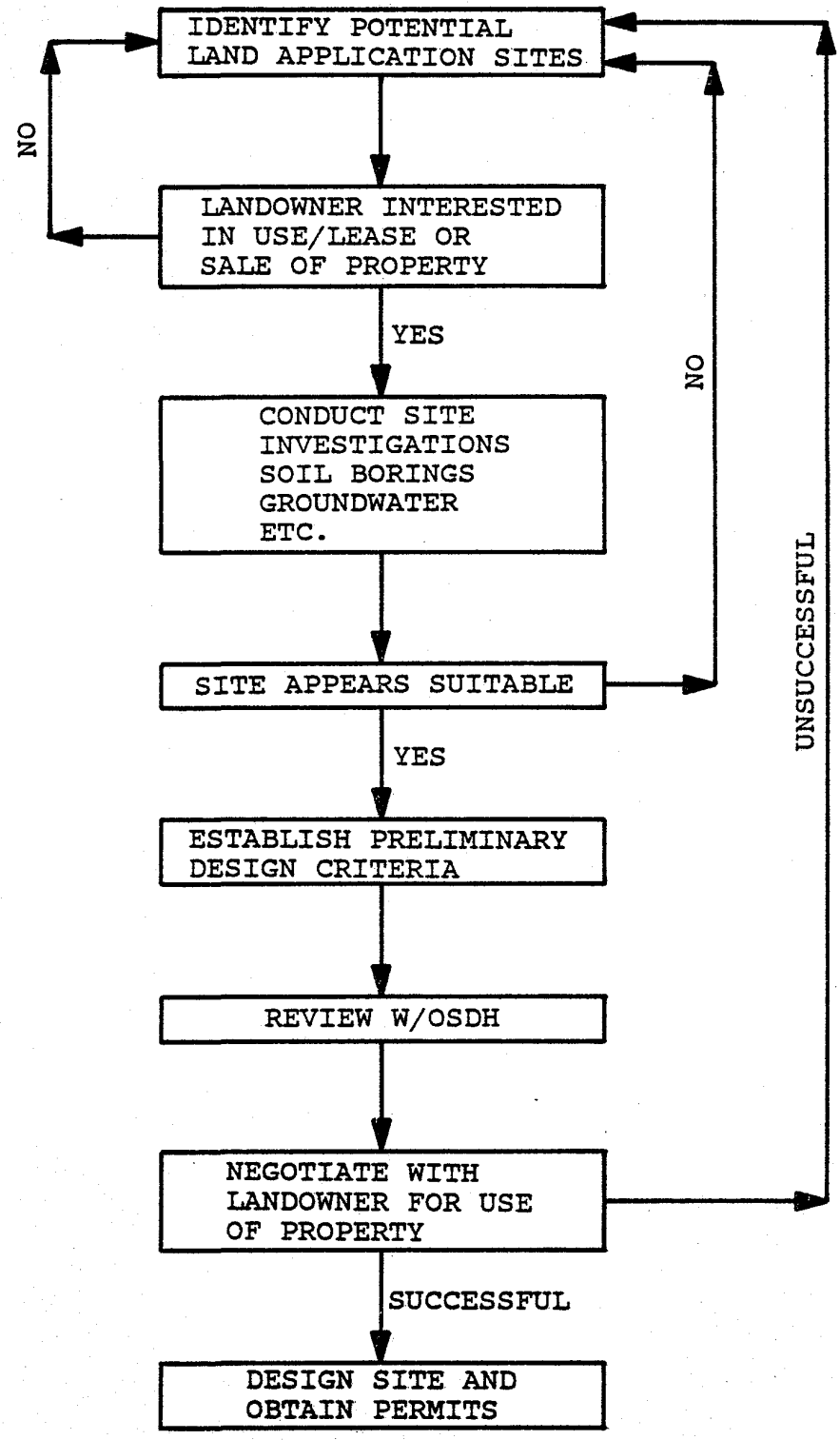
2. Contact landowners to determine availability of site for use as a sludge disposal site.

3. Conduct site specific investigations to establish the suitability of the site.

4. Discuss use of the proposed site with the Oklahoma State Department of Health.

5. Establish final design criteria and a plan for site development and monitoring.

6. Negotiate for use of the land.



HTB, INC.
ARCHITECTS
ENGINEERS
PLANNERS

TAHLEQUAH PUBLIC WORKS AUTHORITY

SLUDGE MANAGEMENT PLAN

SITE PROCUREMENT PROCEDURE

FIGURE NO. 7

ODEQ-115-0001480

VI. OPERATION AND MANAGEMENT

A. GENERAL

Minimizing adverse impacts of a sludge land application system is essential to maintaining public acceptance of the program. Continuous efforts should be made to avoid problems associated with the hauling and application of sludge. The two areas of greatest concern are odors and spillage.

1. Odors. Objectionable odors can result in an unfavorable public reaction and a reduced acceptance of the program by land owners. The following operating procedures are recommended to reduce or eliminate potential problems that can be created by objectionable odors.

   a. Incorporation of sludge as soon as possible after delivery and application to the site.

   b. Frequent cleaning of trucks, tanks and other equipment.

   c. Avoiding sludge application to waterlogged soils, or other soil or slope conditions which would cause ponding or poor drainage of the applied sludge.

   d. Use of proper sludge application rates for application site conditions.

   e. Subsurface injection of sludges. After subsurface injection, the soil should not be disturbed for several weeks, if possible since a second tillage operation a few days later may cause odors.

   f. Isolation of the sludge application site(s) from residential, commercial, and other public access areas.

2. Spillage. All trucks involved in hauling sludge should be designed to prevent spillage. If mechanical or human errors during transport results in a spillage of sludge, cleanup procedures should be employed as soon as possible.

3. Selection of Haul Routes. Routes for sludge haul trucks should avoid residential and commercial areas. Where possible, all-weather access roads should be chosen for land application sites.

B. MONITORING

The OSDH guidelines stipulate that several operating reports must be prepared and filed by the 10th of the month following the reporting period. Copies of the standard report forms to be submitted to the OSDH are included in Appendix D. In the event the concentration of a heavy metal exceeds the standard set forth for that metal an additional Sludge Quality Report must be submitted to the OSDH with a revised form for Determination of Annual Application Rate.

1. **Sludge Activity Report.** A monthly sludge activity report form will be used as a permanent record for locations and concentrations of sludge. If no activity for the month, indicate such and no other reports are required.

2. **Quarterly Application Summary.** A Quarterly Application Summary must be prepared at the end of each quarter. This will serve as a permanent record of nutrients and metals applied on both annual and cumulative basis.

3. **Sludge Analysis Update.** A sludge analysis update report will be prepared on a monthly basis or in the event that more than 100 dry tons (DT) of sludge are being applied monthly, the sludge analysis shall be reported every 100 DT. Actual application rates will be adjusted monthly based on the previous month chemical analysis in order to accommodate variations in sludge quality. The maximum allowable pounds per acre of PA-N shall not be exceeded, regardless of variations in sludge strength. If less than 100 dry tons of sludge are applied, prepare composite sludge sample and analyze during month when aggregate amount equals 100 dry tons per sludge source.

APPENDIX A

CHAPTER 6

"BENEFICIAL USE OF TREATMENT PLANT SLUDGES BY LAND APPLICATION" FROM REGULATIONS FOR SOLID WASTE MANAGEMENT AND FOR SLUDGE MANAGEMENT

ADOPTED AUGUST 8, 1985

CHAPTER 6

BENEFICIAL USE OF TREATMENT PLANT SLUDGES BY LAND APPLICATION

6.0 GENERAL: The following regulations provide minimum standards for the application of water and wastewater treatment plant sludges to land at agronomic rates beneficial as a soil enrichment. It is the intent of these regulations to restrict such land application to that which will benefit the soil and enhance it for crop production and other vegetative growth or to reclaim land that has little agriculture use in its present state.

6.1 Sludge management plans required. Sewage sludge generators or applicators shall submit sludge management plans to reduce the amount of site specific information needed for approval of individual land application sites.

6.2 Sludge generators with approved sludge management plans may distribute or sell Level II and III sludges provided the user completes and signs an information sheet and an agreement to utilize the sludge in accordance with these regulations.

6.3 The sludge generator must keep a record of sludge handled for at least five (5) years after the expiration date of the permit. The sludge records must include:

A. Date of shipment and application

B. Weather conditions, when delivered

C. Location of sludge application site

D. Amount of sludge applied or delivered

E. Quality of sludge

F. Sludge use agreements

G. Area of land applied

The sludge generator is responsible for disposal of the sludge in full compliance with all criteria listed in these regulations.

6.4 The sludge generator is responsible for informing sludge users of sludge quality and to recommend safe application rates and use constraints.

6.5 Sewage Sludge Criteria and Standards

6.5.1 In these criteria and standards three levels of sludge conditioning are referred to as Level I, Level II and Level III. A description of the three levels is as follows:

6.5.1.1 Level I (raw sludge)

Any untreated municipal or domestic sewage sludge derived from but not limited to the following sources; (1) primary and secondary clarifier sludge, (2) septic tank pumpings, (3) holding tank pumpings, (4) primary cell sludges, (5) sludge from grit basins, screens or stilling basins,

6.5.1.2 Level II (Processes to significantly reduce pathogens)

Aerobic Digestion. The process is conducted by agitating sludge with air or oxygen to maintain aerobic conditions, at residence times ranging from sixty days at 15°C to forty days at 20°C, with a volatile solids reduction of at least 38 percent.

Air Drying. Liquid sludge is allowed to drain and/or dry on underdrained sand beds, or on paved or unpaved basins where the sludge is at a depth of nine inches. A minimum of three months is needed, two months of which daily temperatures must average above 0°C

Anaerobic Digestion. The process is conducted in the absence of air, at residence times ranging from 60 days at 20°C to 15 days at 35°to 55°C, with a volatile solids reduction of at least 38 percent.

Composting. Using the within-vessel, static aerated pile, or windrow composting methods, the solid waste is maintained at minimum operating conditions of 40°C for five days. For four hours during this period, the temperature must exceed 55°C.

Lime Stabilization. Sufficient lime is added to produce a pH of twelve after two hours of contact.

Other Methods. Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

6.5.1.3 Level III (Processes to Further Reduce Pathogens)

Composting. Using the within-vessel composting method, the solid waste is maintained at operating conditions of 55°C or greater for three days. Using the static aerated pile composting method, the solid waste is maintained at operating conditions of 55°C or greater for three days. Using the windrow composting method, the solid waste attains a temperature of 55°C or greater for at least 15 days during the composting period. Also, during the high temperature period, there will be a minimum of five turnings of the windrow.

Heat Drying. Dewatered sludge cake is dried by direct or indirect contact with hot gases, and moisture content is reduced to 10 percent or lower. Sludge particles reach temperatures well in excess of 80°C, or the wet bulb temperature of the gas stream in contact with the sludge at the point where it leaves the dryer is in excess of 80°C.

Heat Treatment. Liquid sludge is heated to temperatures of 180°C for 30 minutes.

Thermophilic Aerobic Digestion. Liquid sludge is agitated with air or oxygen to maintain aerobic conditions at residence times of 10 days at 55° to 60°C, with a volatile solids reduction of at least 38 percent.

Other Methods. Other methods or operating conditions may be acceptable if pathogens and vector attraction of the waste (volatile solids) are reduced to an extent equivalent to the reduction achieved by any of the above methods.

Any of the processes listed below, if added to the processes described as Level II, further reduce pathogens. Because the processes listed below do not reduce the attraction of disease vectors on their own, they are only add-on in nature.

Beta Ray Irradiation. Sludge is irradiated with beta rays from an accelerator at dosages of at least 1.0 megarad at room temperature (approximately 20°C).

Gamma Ray Irradiation. Sludge is irradiated with gamma rays from certain isotopes, such as 60 Cobalt and 137 Cesium, at dosages of at least 1.0 megarad at room temperature of 70°C.

Pasteurization. Sludge is maintained for at least 30 minutes at a minimum temperature of 70°C.

6.5.1.4 Other Methods. Other methods or operating conditions may be acceptable if pathogens are reduced to an extent equivalent to the reduction achieved by any of the above add-on methods.

6.5.2 Sludge Use Criteria

Sludge use. Sludge may be used on agricultural land at agronomic rates provided the application is performed in accordance with an approved sludge management plan and the provisions of these regulations.

Level II and III sludges may be applied in accordance with the following:

A. Annual cadmium application rates shall not exceed 0.5 kg/hectare (0.44 lbs per acre).

B. Total cadmium application shall not exceed 5.0 kg/hectare (4.46lbs per acre) if cation exchange capacity is below 5 or the background soil PH is below 6.5, 10 kg/hectare (8.92lbs per acre) if the cation exchange capacity is between 5 and 15 and shall not exceed 20 kg/hectare (17.84lbs per acre) if the cation exchange capacity is greater than 15.

C. Sludges containing greater than 10 mg/kg of polychlorinated biphenyls (PCB's) shall not be applied.

D. Annual sludge application shall not exceed nitrogen and phosphorus fertilization rates for the crop grown and shall not be applied at rates that result in phytotoxicity.

E. Storage of sludge on the application site is not allowed.

F. Sludge shall be incorporated into the soil at the time of application.

G. The access to the general public shall be controlled for twelve (12) months following application of level II sludges.

H. Grazing dairy animals shall be excluded for thirty (30) days from the area where sludge is applied.

I. Direct human consumption food chain crops shall not be grown for eighteen (18) months.

J. Sludge applied to land within the 100 year flood plain shall be applied prior to the rainy season and a vegetative cover established to prevent washout and water pollution.

K. Sludge shall not be applied within 10,000 feet of an airport utilized by turbojet aircraft nor within 5,000 feet of a public use airport utilized by piston engine aircraft unless prior approval has been received from the Federal Aviation Administration.

L. Sludge shall not be applied on land having a slope exceeding 5 percent unless erosion and runoff control provisions are made.

M. Sludge shall not be applied within two (2) feet of the highest seasonal water table nor applied to the land within one hundred (100) feet of a stream or body of water.

N. Sludge shall not be applied within 250 feet of private water supplies.

O. Sludge shall not be applied within 660 feet of a public water supply.

P. Only Level III sludge may be applied to public access areas (for example, parks, golf courses, uncontrolled highway rights-of-way or landscapes, or recreational or other public access areas).

6.5.1.2 SLUDGE USE: Only Level III sludge may be sold or made available to the general public.

APPENDIX B

ANALYTICAL REPORT OF SLUDGE QUALITY

ENVIRONMENTAL CONSULTANTS LABORATORY

1500 UNITED FOUNDERS LIFE TOWER / OKLAHOMA CITY, OKLAHOMA 73112 / PHONE: 405/842-0747

August 7, 1984

ANALYTICAL REPORT: SLUDGE QUALITY
LAND APPLICATION PARAMETERS

SAMPLE: Sludge, as submitted
SOURCE: Tahlequah Wastewater Treatment Facility
Tahlequah, Oklahoma
RESULTS SUBMITTED TO: Rick Garner
HTB, Inc.
P. O. Box 1845
Oklahoma City, OK 73101
DATE RECEIVED: 7/25/84
DATE COMPLETED: 8/3/84
EC LAB # 11847

Chlorides	3,976.
Density *	1.006
Nitrogen, ammonia	3,897.
Nitrogen, nitrate	4,523.
Nitrogen, nitrite	13.5
Nitrogen, organic	40,636.
Nitrogen, total kjeldahl	44,533.
pH **	6.5
Phosphorus	7,753.
% Dry Solids ***	1.0
% Volatile Solids ***	56.
Sulfates	5,964.
Aluminum	9.94
Arsenic	0.85
Barium	198.9
Boron	79.52
Cadmium	7.755
Calcium	24,055.
Chromium	44.26
Copper	724.2
Iron	13,013.
Lead	479.3
Magnesium	2,671.
Manganese	737.2
Mercury	<0.05
Nickel	29.57
Potassium	3,814.
Selenium	<0.1
Silver	120.3
Sodium	8,930.
Zinc	1,650.
Polychlorinated Biphenyls	0.63

All results expressed as milligrams/Kilogram Dry Weight (PPM) unless otherwise specified.
* Grams/mL ** Standard Units *** per cent
< denotes equal to or less than

Ronald L Coleman/wp
Ronald L. Coleman, Ph.D., Laboratory Director

ENVIRONMENTAL CONSULTANTS LABORATORY

1500 UNITED FOUNDERS LIFE TOWER / OKLAHOMA CITY, OKLAHOMA 73112 / PHONE: 405/842-0747

August 7, 1984

ANALYTICAL REPORT: SLUDGE QUALITY-
HAZARDOUS WASTE DETERMINATION

SAMPLE: Sludge, as submitted
SOURCE: Tahlequah Wastewater Treatment Facility
Tahlequah, Oklahoma
RESULTS SUBMITTED TO: Rick Garner
HTB, Inc.
P. O. Box 1845
Oklahoma City, OK 73101
DATE RECEIVED: 7/25/84
DATE COMPLETED: 8/3/84
EC LAB # 11847
PROCEDURE: The sample was subjected to examination consistent with 49CFR Part 261, Subpart C, Paragraphs 261.20 through 261.24 and EPA Publication No. SW-846.

A. IGNITABILITY -- The sample does not pose a fire hazard. It is not ignitable under routine storage, disposal, and transportation conditions.

B. CORROSIVITY -- The sample does not exhibit the characteristics of corrosivity.

pH *	6.5

C. REACTIVITY -- The sample does not exhibit the characteristics of reactivity. It does not react spontaneously, react vigorously with air or water, doesnot generate toxic gases sufficient to present a danger, nor does it tend to explode.

D. TOXICITY -- The sample does not exhibit the characteristics of the Extraction Procedure Toxicity Test (EP Toxicity) by exceeding the established threshold limits.

Arsenic	< 0.01
Barium	2.0
Cadmium	< 0.001
Chromium	0.011
Lead	< 0.02
Mercury	< 0.005
Silver	< 0.002
Selenium	< 0.01
Endrin **	< 1.5
Lindane **	< 1.0
Methoxychlor **	< 3.5
Toxaphene **	< 15.

ENVIRONMENTAL CONSULTANTS LABORATORY

1500 UNITED FOUNDERS LIFE TOWER / OKLAHOMA CITY, OKLAHOMA 73112 / PHONE: 405/842-0747

Analytical Report - Hazardous Waste Determination
EC LAB # 11847

D. TOXICITY Con't. --

2,4-Dichlorophenyoxyacetic Acid (2,4-D) **	<1,000.
2,4,5-Trichlorophenyoxypropionic Acid ** (2,4,5-TP, Silvex)	< 100.

CONCLUSION: The sample, as submitted, does not have the characteristics of a hazardous waste.

All results expressed as milligrams/Liter (mg/L) unless otherwise specified.
* Standard Units
** micrograms/Liter (ug/L - ppb)
< denotes equal to or less than

Ronald L. Coleman/sp

Ronald L. Coleman, Ph.D.
Laboratory Director

APPENDIX C

LETTER DATED OCTOBER 7, 1987
ADDRESSEE: MR. MIKE ARAND, HTB, INC.
ADDRESSOR: DR. BILLY B. TUCKER, OSU COOPERATIVE EXTENSION SERVICE

LETTER DATED NOVEMBER 5, 1987
ADDRESSEE: MR. MIKE ARAND, HTB, INC.
ADDRESSOR: DR. BILLY B. TUCKER, OSU COOPERATIVE EXTENSION SERVICE

1212 N. Jardot
Stillwater, OK 74074
October 7, 1987

Mr. Mike Arand
HTB
P. O. Box 3287
Tulsa, OK 74101

Dear Mr. Arand:

Build-up of toxic concentrations of phosphorus for plant growth from the addition of municipal sewage sludge is highly unlikely. Normal ranges of phosphorus concentrations reported for sewage sludges is generally in the 5,000 to 6,000 mg per liter range. The generic application of 8 tons per acre per year will furnish approximately 90 pounds per acre of total phosphorus. Less than half of this is available for plant uptake. This amount of phosphorus will meet the soil nutrient requirement for most crops. The excess phosphorus above crop needs is sufficiently low that toxic quantities for plant growth will not build up and possible leakage to ground water will not occur.

When phosphorus is applied to soils it reverts to insoluble forms and with time it will be transformed to the same chemical compounds as the innate soil phosphorus. Safe soil loading rates for phosphorus is quite high because phosphorus is immobile in soils and if incorporated it does not run off the surface nor does it leach into ground water. However, if excessive amounts of phosphorus are applied it can become toxic to plant growth. This toxicity is caused by reacting with cations such as the micronutrients iron, zinc, manganese, and copper. The phosphate compounds formed are rather insoluble, hence can create a plant deficiency of the heavy metals, especially zinc. Phosphate induced zinc deficiencies are common in high pH soils where zinc levels are low. Because sludge also contains zinc the likelihood of enough phosphorus being added in sludge to cause soil zinc deficiencies is low.

Available soil phosphorus levels up to 200 pounds per acre have had little effect on zinc and other micronutrient uptake by plants. The amount of phosphorus needed to raise phosphorus concentration to these toxic levels is quite large. The quantity necessary does depend upon the soil and is, therefore, site specific. The soil available phosphorus should be monitored between applications on each field. Results from an agricultural soil testing laboratory are used to determine "available" soil phosphorus. Because of soil test calibrations with specific extraction methods, an "available" soil phosphorus test is also necessary to ascertain phosphorus fertilizer requirements on each crop for a given year. Generalized plant nutrient requirement tables are useful only as guides to get one into a "ball park" figure. The amount of nutrient needed for a specific crop on a given field can only be ascertained by a routine soil fertility test. I urge you to suggest the use of standard soil fertility tests for monitoring effects of sludge application and to determine future sludge rates.

If you stay within the suggested 8 dry tons per acre per year and the total application per field of 25 dry tons, you will not exceed safe soil loading rates for phosphorus. However, I again suggest annual monitoring for soil nitrates, phosphorus, potassium, pH and cadmium. These analyses must be for soil "available" nutrients. Because available nutrient indexes are not standardized the same laboratory must be used throughout the monitoring period.

I trust this report suffices for your purpose. If you have any questions, please contact me.

Sincerely yours,

Billy B. Tucker

Billy B. Tucker
Agronomist and Soil Scientist

BBT/jt

Enclosure

OKLAHOMA STATE

COOPERATIVE EXTENSION SERVICE

DIVISION OF AGRICULTURE • OKLAHOMA STATE UNIVERSITY

Department of Agronomy • 368 Agricultural Hall • (405)624-6425
Stillwater, Oklahoma 74078

November 5, 1987

Mr. Mike Arand
HTB
P. O. Box 3287
Tulsa, OK 74101

Dear Mr. Arand:

I will attempt to answer your question concerning build-up of excessive quantities of phosphorus from sludge applications which contains rather high rates of phosphorus.

The important consideration is the concentration of soluble phosphorus which is residual following land application. Total phosphorus is of little concern. The total amount of phosphorus in normal Oklahoma soils ranges from 4,000 to 8,000 pounds per acre of P_2O_5 in the surface six inches. This translates to approximately 2,000 to 4,000 parts per million. Most of the total quantity is insoluble and does not participate in soil chemical reactions. It is not available for plant uptake. Only a small fraction (normally 20 to 200 pounds per acre in surface six inches) is considered to be soluble and in the available form during the growing season.

When soluble phosphorus is applied to soils it reverts to insoluble forms. The amount that remains soluble and chemically active depends upon the soil and is site specific. Therefore, it is difficult to predict the fate of the added phosphorus and how much will remain available for plant uptake. Studies we have conducted here at Oklahoma State University show that from 10 to 30 pounds of P_2O_5 per acre is required to change the soil test value by one unit. It is assumed that the soil test is measuring the easily available phosphorus.

The system universally accepted is to apply phosphatic fertilizers in sufficient quantities to achieve the yield potential and then measure any residual available phosphorus by subsequent soil sampling.

My recommendation to you in land application of the relatively high phosphorus sludge is to apply the sludge commensurate with nitrogen needs for the crop. Then annually monitor the soil-test phosphorus. I strongly recommend that you use the OSU Analytical Services Laboratory for testing the soil. This gives continuity to the program and allows for the use of tests which have been calibrated for Oklahoma conditions.

A phosphorus level of 65 or greater with the OSU test indicates a plentiful supply of available phosphorus for the growing season. On low zinc soils the level should not exceed 200 and I would be concerned about other metals such as copper, iron, and manganese if the value exceeded 400.

I am expecting that it would take several years to build levels up to 400 on most soils, especially if the soil remains acidic.

I hope this helps you in developing your program. Feel free to call if you have further questions.

Sincerely,

Billy B. Tucker

Billy B. Tucker
Extension Agronomist

BBT/jt

Enclosure

APPENDIX D

SAMPLE FORMS

A. LANDOWNERS AGREEMENT

B. SITE INFORMATION WORKSHEET

C. FORM FOR DETERMINATION OF ANNUAL APPLICATION RATE

D. SLUDGE ACTIVITY REPORT

E. QUARTERLY APPLICATION SUMMARY

F. SLUDGE ANALYSIS UPDATE

G. DAILY SLUDGE REPORT FORM

H. AEROBIC DIGESTION OPERATION REPORT

LANDOWNERS AGREEMENT
AGRICULTURE BENEFICIAL REUSE
PLOT PLAN

Land Owners Name: _____
Address: _____
Phone Number: _____

This letter is for the purpose of authorizing the application of sludge to my farm located: (Include County) _____

_____

_____

Below is a list of conditions I have agreed to follow and will report any of these conditions which are violated.

1. Dairy animals shall be excluded for thirty (30) days from the area where sludge is applied.

2. Direct human consumption food chain crops shall not be grown for eighteen (18) months.

3. The access to the general public shall be controlled for twelve (12) months.

4. Sludge shall be incorporated into the soil at the time of application.

5. Sludge applied to land within the 100 year flood plain shall be applied prior to the rainy season and a vegetative cover established.

6. Sludge shall not be applied to land having a slope exceeding 5 percent.

7. Sludge shall not be applied within two (2) feet of the highest seasonal water table.

8. Sludge shall not be applied to land within 100 feet from a stream or body of water.

9. Sludge shall not be applied within 250 feet of a private water supply or 600 feet of a public water supply.

10. No off site storage of sludge. No stockpiling of sludge.

11. Sludge should be applied only to soil having a pH of 6.5 or greater. The soil may be treated with lime to raise the pH before sludge application.

12. Each annual application must be followed by a crop.

Landowner's signature _____ Date _____

SITE INFORMATION WORK SHEET

Site LOCATION	CROP	GROSS # ACRES	ACTUAL # ACRES APPROVED	DEPTH OF WATER	SOIL PH	SOIL CEC	COMMENTS

t any areas or special circumstances concerning this site:

: any parts of this site not suitable for application

FORM FOR DETERMINATION OF

ANNUAL APPLICATION RATE

1. Crop to be planted: _____

   Required LBS/A PA-N: _____ LBS.

2. Determine PA-N value of sludge:

   TKN _____ ppm

   Minus NH_3-N _____ ppm

   Minus NO_3-N _____ ppm

   Organic N = _____ ppm

   20% Organic N = _____ ppm

   Add NH_3-N _____ ppm

   Add NO_3-N _____ ppm

   PA-N _____ ppm

   Convert PPM to LBS/DT, Multiply by 0.002= _____ LBS/DT

3. Determine dry tons per of sludge:

   Required LBS/A PA-N _____ LBS

   Divide by LBS PA-N/DT _____ LBS

   Dry Tons/Acre _____ DT/A

4. Cadmium Content of Sludge _____ ppm

   $\frac{.446 \text{ X } 500}{\text{ppm Cd}}$ = _____ Dry Tons/Acre/Year

5. Annual Sludge application rate will not exceed _____ Tons/Acre.

First Day of Application _____
*Reports Submitted Monthly or
Every 100 DT of Sludge Applied.

Application Site: _____
Number of Acres: _____
Maximum DT/A/yr: _____

SLUDGE ACTIVITY REPORT

DATE	GALLONS APPLIED	DRY TONS APPLIED	ACREAGE OF APPLICATION	DRY TONS PER ACRE	WEATHER CONDITIONS	COMMENTS: LIST EQUIPMENT FAILURE
YEAR TO DATE						
SUB T.						
TOTAL						

QUARTERLY APPLICATION SUMMARY

ERIOD BEGINS: ____/____/____ YEAR APPLICATION BEGAN: _____

ERIOD ENDS: ____/____/____ DATE: _____

SITE: _____

NUMBER OF ACRES: _____

Report Results in LBS/Acre or DT/Acre

PARAMETER	LAST REPORT	THIS PERIOD	THIS YEAR	LIFETIME
PA—N				
P				
K				
Pb				
Zn				
Cu				
Ni				
Cd				
Cr				
Other				
Other				
Total Dry Tons This Field	DT/A	DT/A	DT/A	DT/A

Comments:

I certify that the above numbers are accurate.

_____

Signature

SLUDGE ANALYSIS UPDATE

PERIOD BEGINS: ____/____/____ PERIOD ENDS: ____/____/____

SLUDGE FACILITY: _____

LAB PERFORMING CHEMICAL COMPOSITE (every 100 DT):

SLUDGE PARAMETERS	ppm/mg/l/MG/KG CONCENTRATION	LBS/DT	LIST ANY CHANGES & COMMENT ON APPLICATION – CHANGE
PA–N			
P			
K			
*Pb			
*Cd			
Zn			
Ni			
Cr			
Cu			
Other:			

% Solids of Sludge: _____

Figure Maximum Cd. Dry Tons/Acre: For all different crops – Show work

$$\frac{.446 \times 500}{\text{Cd ppm}} = \text{\_\_\_\_DT/A\_\_\_\_}$$ (Not to exceed 8 DT/A)

DAILY SLUDGE REPORT FORM

TAHLEQUAH, OKLAHOMA

DATE	TIME LOADED	TRUCK NUMBER	LOAD NUMBER	% SOLIDS	POUNDS LOADED	APPLICA SIT

OPERATION REPORT FOR TAHLEQUAH, OKLAHOM

AEROBIC DIGESTION

MONTH_____, 19__

DATE	DIGESTER BASIN NO. 1											DIGESTER BASIN					
	RAW SLUDGE		BASIN MIXED LIQUOR					DIGESTED SLUDGE			% REDUCTION OF VOLATILE SUSPENDED SOLIDS	RAW SLUDGE		BASIN MIXED LIQUOR			
	VOLUME (gals)	VOLATILE SUSP. SOLIDS (mg/l)	TOTAL SOLIDS (mg/l)	TOTAL VOLATILE SOLIDS (mg/l)	SUSP. SOLIDS (mg/l)	VOLATILE SUSP. SOLIDS (mg/l)	D.O. (mg/l)	VOLUME (gals)	VOLATILE SUSP. SOLIDS (mg/l)	SUSP. SOLIDS (mg/l)		VOLUME (gals)	VOLATILE SUSP. SOLIDS (mg/l)	TOTAL SOLIDS (mg/l)	TOTAL VOLATILE SOLIDS (mg/l)	SUSP. SOLIDS (mg/l)	VOLAT SUS SOLI (mg/
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METHOD OF OPERATION

____ SERIES
BASIN NO. ____ IS PRIMARY DIGESTER
BASIN NO. ____ IS SECONDARY DIGESTER
____ PARALLEL

REMARKS: _____

ODEQ-115-0001506